

ALERTNESS AND MOTOR ABILITIES OF ATHLETES AND NON-ATHLETES

BY
G. WILSON SHAFFER

A DISSERTATION SUBMITTED TO THE BOARD OF UNIVERSITY STUDIES
OF THE JOHNS HOPKINS UNIVERSITY IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR
OF PHILOSOPHY
1928

Reprinted from MENTAL MEASUREMENT MONOGRAPHS
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HISTORICAL

The vital importance of the relations which exist between the mental and physical makeup of an individual has long stirred the interests of both scholar and layman alike. This interest has resulted in the promulgation of numerous investigations carried on with varying degrees of scientific technique and with a multiplicity of measurements. Due to these numerous standards and methods, as well as to the various interpretations of terms employed, considerable confusion has developed. A discussion of these methods and combinations of methods is given.

From crude measurements of height and weight as a basis for testing physical development, the study progressed through the use of height-weight indices, vital capacity, standing and sitting height measurements to finer motor adjustments as measured by such tests as tapping, card-sorting, steadiness, strength of grip, reaction time, and finally to the big muscle tests of running, jumping, throwing and climbing.

Likewise, various criteria of mental development have been used. These criteria range from teachers' estimates of ability and school grades to mental tests and I.Q.'s.

An infinite number of combinations of these physical criteria have been used by various investigators in the field. The early investigators were concerned with the relation between height-weight, and grade accomplishment or teacher's estimate. Other students of the problem showed a progression in the testing of mental development and attempted to correlate the same physical measurements with mental tests or I.Q.'s.

Later investigators have used tests of fine motor ability or even big muscle tests as physical criteria, and have combined with these, general intelligence tests or tests of special mental factors.

A summary of early investigators in the field would indicate the following: Using physical measurements such as height and weight, and teachers' estimates or age-grade standards as criteria for mental development, Pearson, Porter, MacDonald, Zirkle, Pyle, Roberts, Boas, Burgenstein, Crampton, Smedley, Hogue, DeBusk, Baldwin and Arnold agree that a positive correlation

exists, while West, Gilbert and Bagley find little or no, and in some cases even negative correlation.

A detailed discussion of the studies of these early investigators in the field is given by Stalnaker (50).

A definite progression in the method of testing was accomplished when Bagley (3) discarded as a basis for judgment of physical ability the simple height and weight measurements previously used, and added to class standing and teachers' estimate as bases for judgment of mental ability, the testing of a special mental factor termed alertness.

The various tests to which the subjects were submitted were as follows:

A. Tests of motor ability

1. Strength
2. Rapidity of voluntary movement
3. Accuracy of voluntary movement
4. Steadiness or control of voluntary movement
5. Amount and character of involuntary movement
6. Teachers' estimate of motor ability

B. Tests of mental ability

1. Various types of reaction times are representing quantitatively the mental ability of the subject, mental excellence being represented by the alertness of the mind in reacting appropriately to the various stimuli
2. Class standing of the pupils
3. Teachers' estimate of mental ability

With these experiments Bagley's results show a direct disagreement with those of Porter. He concludes that under the condition of his investigation the brighter pupils are as a rule deficient in motor ability, while those who are the best developed physically are generally deficient in mental ability. He found, however, many individual exceptions and a varying validity at different periods of development.

The next attempt at the solution of the problem was made when Wissler (55) in 1901 tested a large number of men from Columbia College and some few women from Barnard College. He examined the students by means of tests for memory, pitch, color naming, association, marking A's and reaction time, per-

ception of size, perception of weight, sensitiveness to pain, sensation areas, color vision and color preference, fatigue, rate of movement, accuracy of movement, rhythm and perception of time, along with measurements of height, weight, size of head, strength of hand, eyesight and hearing.

When, after seven years he concluded his experiments, he stated that his results showed that physical tests showed a general tendency to correlate with themselves; also that markings of students in college classes correlate with themselves to a considerable degree; but that neither physical tests nor class standing correlate with psychological tests of the laboratory type. He further concluded that a negative correlation exists between physical development and mental ability. This disagreement with the results obtained by Porter and Smedley may be explained, he says, by the fact that college students have reached physical maturity, while the students with whom Porter and Smedley worked were growing children.

In the same year in which this work was carried on by Bagley and Wissler in this country, Chamberlain (15) reported some studies carried on in other countries along the line of Dr. Porter's St. Louis work. In Prague, Bohemia, children between five and a half and fourteen years were tested to determine the relation which exists between bodily development and intellectual activity. The results showed an agreement with the point of view used by Dr. Boas in his criticism of Porter's work; namely, that the fact that the physically weaker children are in the lower grades, is not a conclusive indication that the physically superior children are likewise mentally superior, but may be due simply to the regular school attendance made possible for these children as a result of their healthy physical condition.

Significant contributions to the field have been made by the studies of Crampton 1908 (17), Baldwin 1914 (4, 6), Rotch 1909 (45), Foster 1910 (26), King 1914 (33), who emphasize the importance of physiological age over chronological age.

In his study based on 4800 records Crampton (17-19) shows that each chronological age group contains three subgroups based upon physiological age; namely, (a) prepubescent, (b) pubescent,

(c) post-pubescent. According to him the variability in the appearance of secondary sex characteristics is great. The total normal range of pubescence, for instance, is about eight and a half years and the variability one and a half years. This is so great that we cannot predict with even a fair degree of accuracy, the one feature from the other. Crampton makes the point that in an attempt to correlate scholarship and physical development as measured by height, weight and strength, previous investigators have failed to take into consideration the physiological age of their subjects. This is a matter of great importance since the work of Crampton shows that pubescence is accompanied by an increase in height, weight and strength. He found that the post-pubescents averaged from 24 to 33 per cent heavier than the pubescents of the same age, and that they averaged as much as eleven per cent taller. The post-pubescents were found to be superior in strength also. There was, however, one important difference in strength—that is the fact that at the ages of 15.75 to 16.25 the pubescents are weaker than the prepubescents. This is unprecedented and points to the conclusion that if pubescence takes place at so late a date as this, it causes a temporary diminution of motor force. This coincides with the unscientific belief that periods of rapid physiological change are periods of vulnerability, a fact which is by no means the case of other than this restricted group. The factor of pubescence was taken into consideration also in relation to scholarship. After dividing the age groups into classes of prepubescents, pubescents and post-pubescents, the actual performance in scholarship was recorded for each group. His results showed that 9, 10 and 7 per cent more post-pubescents “pass” at the respective ages of 13, 14, 15 years than do prepubescents.

These physical and mental differences between the post-pubescents and the prepubescents are sufficiently great, then, to warrant their being given careful consideration in any study upon mental characteristics of the ages about puberty.

Crampton concludes finally that,

“There is little or no relation between scholarship and weight except in so far as their relation to pubescence relates them to each other. This

explains Porter's and Smedley's work. The greater the number of post-pubescents in any group, the greater will be the weight of the group. Then—scholarship does not bear any marked primary relation to weight-height-strength, etc., though they are all affected in the same direction of pubescence. The only real relations of scholarship are: a probably negative relation to weight, a probably positive relation to height, and a possibly positive relation to strength. Their mutual relation with pubescence is the most important feature."

Rotch's (45, 46) work indicates that it is the anatomical age, rather than the chronological age, which corresponds to mental ability and that anatomical development goes on largely independent of height, weight, and chronological age. He calls to our attention the case of three boys, ages seven, eight and nine respectively, all of whom were in the third grade. Although their chronological age differed, their place in school would indicate that they were about equal in mental development. When the Roentgen picture of the carpal bones of the wrist was taken, it was found that their anatomical ages were also equal. He states, therefore, that the anatomical age is more likely to correspond with the mental ability, than is the chronological age.

In his reports on the educational experiment of "Physiological Age as a Basis for the Classification of Pupils Entering High School" Foster (26) states that a higher percentage of promotion occurred when the physiological age was used as a basis for classification, than when the usual grade method was used. He also states that since height correlates highly with the advent of puberty, a classification according to this criterion would probably produce the same results.

The next important contribution to the field was made by King (34) who published in 1914 the results of his study on "Physiological Age and School Standing." The object of his study was to record as accurately as possible the incidents of physiological maturity with special reference to school tasks and to progress through the grades. All pupils between the ages of $10\frac{1}{2}$ and 17 years were considered in an attempt to discover: (a) whether in this group of pupils, there is any difference in school ability and school progress in the three stages of development, (b) whether

maturing at a later chronological age than usual is less favorable to the individual than at an early or median age, and (c) whether the physiological age has an observable relation to elimination from school. King states that the method of arriving at the degree of maturity reached by each pupil was based on Dr. Foster's statement that where physical examination could not be made, a fairly accurate classification of pupils according to physiological age could be made on the basis of height and general physical appearance. Consequently, the degree of maturity in this experiment was estimated by the principal and a discriminating woman teacher, through careful observations of the height and general physical appearances of each pupil. The results obtained by King are in agreement with those set forth by Dr. Crampton in his study of New York school children. King concluded that girls that had matured did better work than the immature ones of the same age, and that they were more frequently found in the upper classes than in the lower ones. The same conclusions were reached with regard to boys in all groups but one.

Of particular interest is the work of Baldwin (4), who made the first attempt to follow the same group of children through the elementary and high school in physical growth or school standing. In his experiments 43,840 physical measurements were made on approximately 1000 boys and 1000 girls and 21,683 final quarterly term marks of 135 of these same boys and girls from the Horace Mann School of Teachers' College, New York City, the University of Chicago Elementary and High School and the Frances W. Parker School of Chicago. Baldwin concludes as regards the relation of physical growth to school standing, "If pedagogical age is to be accepted as a fair equivalent of mental development, tall, heavy boys and girls with good lung capacity are older physiologically and further along in their stages toward mental maturity as evidenced by school progress than the short, light boys.

In a later investigation Baldwin (6) used the Stanford Revision of the Binet-Simon tests to determine the mental development, and with 49 girls as subjects, found a positive correlation existing

between mental age and height, weight and exposed area of carpal bones. The correlation between growth in height and mental age was $+0.89$, between growth in weight and mental age $+0.71$, and between the exposed area of carpal bones and mental ages $+0.83$.

A group of studies carried on by Goddard (30), Simon (47) and Mead (37), with feeble-minded children as subjects, point to a definite correlation between physical and mental development. As a result of his many years of research in the field of the feeble-minded, Goddard decided that the children of this type are consistently shorter and lighter, age for age, than the normal children and that this difference increases with age, although girls seem to deviate less from the normal than do the boys.

Mead (37), working with both feeble-minded and normal children, classified his subjects with regard to age and mental ability. This classification was based, in the case of normal children, on their actual school grades, and in that of the feeble-minded, on the estimates of those who had them in charge. He treated the data under four heads: (a) The age of walking and talking in relation to general intelligence. (b) Height and weight of children in relation to general intelligence. (c) Strength of grip and dextrality in relation to general intelligence. (d) Perception and memory in relation to general intelligence. Mead's results with regard to the relation of height and weight to general intelligence are similar to those of previous investigators with the feeble-minded. They show that physical growth is decidedly checked in the mentally defective. This condition he finds more clearly displayed in height than in weight, a result probably due in part to the fact that height is less likely to be conditioned by regular habits of sleep and diet.

Earl E. Wilson (54), principal of the Rogers School, Stamford, Conn., experimenting in March 1916 with 128 elementary school boys, was responsible for a definite progression of method in attacking the problem. The purpose of the investigation was to determine whether there exists any relation between athletic ability and mental ability of elementary school boys, and so far

as I am able to determine this is the first study on the relation of big muscle skill to mental ability.

In order to obtain information as to physical ability, athletic tests were given to the boys in grades five to eight inclusive. These pupils were first classified according to weight, and then were timed in dashes of 60, 70 or 100 yards, depending upon their weight and classes. The other big muscle tests given included the standing broad jump, baseball throw for distance, and running high jump. The physical ability score for each boy was obtained by averaging his individual scores in each event. The mental ability was reckoned by averaging the marks that appeared on the report cards from the third grade up. The coefficient of correlation between the two marks was found to be 0.0528, with a probable error (P.E.) of 0.0529, showing no correlation whatever. The boys who stood highest in the athletic tests were, as a whole, no better in their scholastic standing than the boys who stood lowest in the athletic events.

Ten years later Fischer (25), in a study of 2430 Philadelphia school children, reached a conclusion in disagreement with that of Wilson. The two studies, however, were not exactly the same. In Fischer's study, scholastic grades and promotion were correlated with tests of big muscle variety in which certain passing grades had been set up. These tests included running, jumping, throwing, and climbing, which are the elements of physical ability. Fischer's results indicated that in most cases high classes mentally or scholastically are also the high classes physically.

Wolley and Fisher (56) in 1914 gave a battery of tests to 753 working children fourteen and fifteen years of age, in an attempt to get at mental and physical measurements. The tests included the following: height, standing and sitting, weight, vital capacity, visual and auditory acuity, grip, steadiness, cancellation, substitution, card sorting, tapping, association, opposites, sentence completion, rote memory, various form board tests and a puzzle box test. The result of each test was correlated separately with school grade. A positive correlation was found to exist between school grade and all of the physical tests except steadiness, in the case of the boys. The girls' results, however, showed no corre-

lation with strength of hand or with tapping when continued as long as a minute. All of the mental tests were found to correlate positively with school grade, that of memory being the highest.

In 1917 Bickersteth (8) gathered some physical and mental measurements of 2500 elementary and secondary school pupils. The mental age of his subjects was determined by a series of mental tests, including attention, discrimination, memory, reasoning, and analytic and synthetic apperception (spot pattern). Motor tests, including tapping and plunger, were used as a means of arriving at the physical age. The conclusion reached was that the degree of correlation of the motor with the mental tests gives no support for the evidence of any close relationship between motor and mental ability.

An experiment very different from those which have previously been discussed was carried on by J. F. Williams (53) in 1922. This investigation was a comparative study of formal gymnastics and play for fourth grade children. There were selected two groups equal in mental ability. That is, the median age of the two groups was 113 and 114 and the range from 96 to 146 and from 100 to 148. The groups were then equalized as nearly as possible for motor ability, posture, growth and development. Both groups were subjected to a group of tests including height, weight, lung capacity, girth of chest, strength of arm, alertness (crossing out dots and crosses), bean bag throw, thrusting and balancing. After the groups had been equalized, the one group was given two periods weekly of formal gymnastics and the other group the same amount of time in plays and games. At the end of a training period of eight months the initial tests were repeated. The difference in the results of these tests, on the whole, favored the play and game group, the means of the gains in this group being larger in all tests but three; namely, chest expansion, strength of left fore-arm and thrusting. Williams states, however, that there was practically no reliability in the difference for any test except alertness. This conclusion seems to indicate that alertness is a factor which is developed to a greater degree in plays and games than in formal gymnastics.

Dowd and Arlitt (22) carried on an investigation similar to

that of Williams, with an attempt to control several conditions which they felt might be important factors in determining the results. The investigation was carried on with 35 girls living in a summer camp in Maine. Thus, the experimenters were able, to a certain extent, to control the hygiene of rest, sleep and nutrition. The experimenting period was an extensive one of five weeks' duration and the training times for the two groups were arranged for the same hour of the day. The subjects ranged in age from 7 to 18, with an average age of 13.22. The groups were chosen in the following manner: the Pintner non-language tests and nineteen motor tests were given to all of the subjects at the outset. The individuals were then shifted about until the groups were practically equal in average motor test score, average mental test score and average chronological age. The one group was then given a twenty minute period of formal gymnastics at 9 a.m. daily except Sunday, for the first week, and a thirty minute period for the next four weeks. The exercises were given according to the regular Swedish system and the instructor reports that the class showed progress in gymnastics at the end. The other group, which was called the supervised play group, had plays and games at the same hour and for the same length of time. The plays and games consisted of dodge ball, relay races, health stunts, push up, chinning the bar, head stand, hand walk, hawk dive and balancing with chairs. At the end of the training period, the same tests were repeated with the two groups, in the original order. The play and game group proved to be superior in twelve tests, including cancellation, card sorting, tapping, left hand weight lifting, balancing, target aiming, right hand grip, left hand grip, baseball throw, basketball throw, 75-yard dash, and running broad jump. The formal gymnastic group had better records in right hand tapping, bean bag aim, hopping in circles, vital capacity, running hop step and jump, and standing broad jump.

In conclusion the investigators state that in the baseball throw and the basketball throw, both of which are supposed to involve general bodily coördination, the play and game group showed superiority, while in the bean bag throw, the formal group had the better performance. This fact, they point out, is in contra-

distinction to the popular belief that formal gymnastics are more valuable for the development of coördination. (No mention, however, is made of the fact that the formal group also excelled in the hop, step and jump, which involves as much bodily coördination as any of the tests given.) In a final statement the investigators say that training in formal gymnastics produced no greater effect than the same length of time spent in play.

Westerdays (50) in 1923, experimenting with 46 women, freshmen and senior physical education majors at the University of Wisconsin, correlated the results of Form A of the Terman Group Test, Form I of the Thorndike Intelligence Examination for High School Graduates, teachers' estimate of physical efficiency (coördination) and average academic grade with the results of an agility time test and a test of coördination. In attempting to embody the important qualities that would measure physical efficiency Westerdays devised the following tests:

(1) *Agility Time Test*—The student started at a signal, ran forward and “(1) jumped over a rope two feet from the floor; (2) climbed a rope ladder attached to the floor, touched a rung ten rungs from the floor, and stepped on each rung during descent; (3) rolled over on a mat touching the shoulders to the mat; (4) crawled under a horse and finished running across the line.” The time required to complete this test was taken with a stop watch.

(2) *Coördination Test*—“This was a front leaning rest on the horizontal bar. It was demonstrated once, then each student was given a practice trial, after which she was graded according to push up, arch in back, position of feet and head. The three instructors who gave these tests had a definite arrangement beforehand on the method or presentation of the tests, the important points that would be graded, and how much would be taken off for each one.”

In summing up the results of these tests Westerdays found a good correlation between agility time and coördination and a minus correlation between agility and mental capacity and between coördination and mental capacity.

Evelyn Garfiel (27), working with Barnard College women, contributed some notable work on the measurement of motor ability. The investigator attempted to answer the following questions:

- (1) What is the intercorrelation of various tests that purport to measure motor ability?

- (2) What criterion for motor ability can we use and what is its reliability?
- (3) Can we arrange a team of tests that will correlate highly with such a criterion?
- (4) In the light of these, what is the nature of motor ability, and can we justly speak of a motor ability?
- (5) What is the relation of this ability to general intelligence?

The aspects of motor ability were catalogued under five heads:

- (1) Speed
- (2) Accuracy of voluntary movement, i.e., coördination
- (3) Control of involuntary movement or steadiness
- (4) Strength
- (5) Motor adaptability, i.e., capacity to solve motor situations, to make a new coördinated movement accurately.

Regarding motor adaptability the investigator states,

"It is easy in a regular gymnasium class to see that the students differ, not only in speed and strength of movement, but also in their ability to see through a motor situation, I mean merely to make quickly a difficult new reaction. Whether the superior student can do the 'ladder' or 'horse' stunt correctly the first time because she has more complex systems of coördinated movement habits at her command, or whether she can do this because she has more general ability to quickly form and raise such coördinated movements remains to be seen. But whatever the factor determining this ability may be, it is obvious that properly to differentiate between people with good and with poor motor ability we must allow for this factor of speed of motor learning."

The final team of tests selected for the experiment were:

- (1) Running
- (2) Picking up paper
- (3) Strength of back—by dynamometer
- (4) Tricks
- (5) Steadiness
- (6) Tapping
- (7) Leg strength—by dynamometer
- (8) Hand strength—by dynamometer

Criterion-judgment of physical education instructors correlated 0.77 with the results in motor ability tests. Second rating

correlated 0.92 with the first, thus establishing the idea that there is such a thing as motor ability and that it is meaningful.

Of significance in the conclusions is the fact that Garfiel ventures a guess that with the Army Alpha as a basis for mental tests mental and motor abilities tend to a very low positive relation.

In 1922 Elizabeth Stalnaker (50) approached the subject with a comparison of certain mental and physical measurements. The subjects used in the experiment included 64 college freshmen, 135 pupils in a private school from the fifth grade up through high school, and 425 public school pupils of the seventh, eighth, ninth and tenth grades of the junior and senior high schools. The age range of this entire group was from nine years and six months to twenty-two years and two months. The data gathered included the scores on a group of seven Hopkins special tests, (1, an attention test; 2, a substitution test; 3, a memory test; 4, a second substitution test; 5, a second memory test; 6, omitted letter test and 7, a second attention test), scores on group intelligence tests and the physical measurements of weight, standing height and trunk length, vital capacity, chest circumference and social data as to place of birth of each subject and that of his or her parents.

The investigator states that there is either no correlation between the physical standard of the ratio of height to weight and intelligence scores, or that the measurement which we have for determining the one or the other of the two terms mentioned are inadequate to measure them. In her summary she says,

"One is forced to conclude, therefore, that there is no relation between the physical development measured by the height-weight ratio of certain accepted standards and mental development also measured by certain accepted standards, whether they be group or special psychological tests. This does not dispose, however, of the possibility of a relationship between physical and mental development. The height-weight index may not be an accurate measure of physical development, or the tests may not measure mental development. In the case of mental measurement, however, there are objective criteria by which to gauge the extent to which they achieve their purpose, while as yet, there are no such definite criteria for the physical measurements. One is tempted, therefore, not to accept the validity of the height-weight index as an adequate measure of physical fitness, or at

least of the kind of physical fitness which is demanded in the performance of mental tests."

During the year 1922-23, certain measurements of performance involving motor control, speed, and accuracy were made upon college students by Roy M. Dorcus (23). The subjects for the experiment included (a) a group of twenty men of the Johns Hopkins University track team, (b) a group of twenty male students of the Johns Hopkins University who had never engaged in any organized athletic activity and indulged little in games, (c) a group of students (women) in Goucher College who were engaged in athletics of some sort, (d) a group of Goucher students who were not or had not been engaged in any athletics. The tests, used in the investigation were, (a) steadiness, (b) tapping, (c) a dynamometer test, (d) card dealing and color naming, and (e) two forms of graphic coordination tests, and were administered in the order listed. The series of tests were made upon groups 1 and 2 at two different periods. The first series of tests were made about the second and third weeks of January before the athletic men did any athletic work. The second series was made during the third and fourth weeks of May, after the athletic men had participated in athletics during that period. The results showed:

(1) The male athletic group is superior to the non-athletic group in the tests used, if both trials be considered. The only test in which the athletic group was inferior to the non-athletic group on the first trial was the steadiness test, and the relation was reversed on the second trial.

(2) The athletic women are superior to the non-athletic women, and the relative superiority of the athletic women over the non-athletic women is greater than the superiority of the athletic men over the non-athletic men.

(3) Both male groups are superior to the female groups except in coordination test no. 2 and color naming.

(4) The improvement of the athletes on the second trial (i.e., after athletic training) was greater when improvement occurred, than that of the non-athletes, excepting in color naming test and coordination test no. 1.

An interesting angle of the problem was presented by Landis, Burt and Nichols (35), working at Ohio State University. In a preliminary statement the authors make the statement that studies in the past have utilized, on the physical side, relatively small groups of muscles, such as those involved in grasping a dynamometer. The more important problem, they claim, is the functioning of the large muscle groups and their coordination when the whole organism is in action, as in running, jumping, vaulting, throwing, and climbing.

Five hundred and fifty-nine freshmen were given four big muscle tests consisting of the 100 yard dash (one trial), the running broad jump (three trials—best jump), baseball throw (at 4 foot target—90 feet distance), and a fence climb (8 feet high—climb over, touch ground and return). The mental test given was the Ohio State University Intelligence Test, similar to Army Alpha. The correlations obtained between intelligence and the big muscle tests were as follows:

Intelligence and 100 yards dash.....	0.01
Intelligence and running broad jump.....	0.03
Intelligence and fence climb.....	0.07
Intelligence and baseball throw.....	0.04

The probable error of these coefficients is approximately .03.

The writers expressed the opinion that running, jumping, throwing and climbing form an adequate basis for testing large muscle movements, and in so far as these can be considered as indicators of general physical efficiency, there is no relation between the latter and intelligence.

Burt and Nichols (10) follow this study with one on the "Intelligence of Varsity Athletes," as determined by the Army Alpha modified to fit the needs of Ohio State University. An attempt was made to show the differences between the averages for the entire university student body and the averages for separate groups of athletes as in cross country running, tennis, golf, track, baseball, basketball, football, and wrestling. It is pointed out by the writers that any interpretation of the facts would be doubtful, but that they do add some interesting comments on the study.

"The four sports which seem to rank highest; namely, cross country running, golf, tennis and track, are sports where individual prowess predominates, while three of the others involve distinct coördination of the members of a team."

"There is a decided difference between the total athletic group and the total University group and the conclusion here is that "the athletes are on the average about eight percentile lower in intelligence than the average upper-classman, and that this is due to a smaller number of athletes of high grade rather than to a preponderance of those of low grade."

A careful examination of the results and attempts to enterpret them suggested to the writers the probability that a relation exists between athletic interests and intelligence rather than between athletic ability and intelligence.

A study somewhat like that of Burt and Nichols was carried on by Remp (44) at the College of Wooster. The study covers 327 men of the classes 1923-24-25. Remp divided his subjects into three classes. Class one consisted of the men who had earned the college letter by participation in inter-scholastic contests as members of some team; football, baseball, basketball, track, cross country, tennis or swimming. In this group there were 68 men, or 20 per cent of the total number of subjects. Class two included those who did not make the varsity teams, but were good second team material and intra-mural athletes, 46 men or 15 per cent. The rest of the men, 213 in all, or 65 per cent of the group, were called non-athletes and placed in class three. The Army Alpha General Intelligence Test was given to all the subjects.

Remp reached the following conclusions:

1. "In intellectual capacity as indicated by scores in Army Alpha, varsity athletes rank higher than non-athletes. Football men rank higher than non-athletes but lower than other varsity athletes.

2. Of varsity athletes a much larger percentage remain throughout four years and graduate than of any other group.

3. In scholarship, non-athletes and athletes are practically the same at the higher levels of B and above it; the non-athletes are more numerous at the lower levels of D and D+; the athletes are more numerous at C."

One of the most recent studies of major importance was carried on by Kenneth S. Heaton (32) of Boston University. The children tested were chosen by the 11, 12 and 13 year old groups in

public schools and numbered 102 in all. He compares the physical ability and development of children of low intelligence with that of children of high intelligence. All of the children had previously been given one or more group intelligence tests and had been assigned percentile ratings according to standard percentile tables for each test. The physical measurements used were: height, weight, chest expansion, push up, and 75 yard dash for both boys and girls, the running broad jump for boys and baseball throw for girls. The push up test probably deserves special mention, since Heaton believes it to be the most valuable one used: The child lies face downward on the floor with hands on the floor even with his shoulders. With back and knees stiff, he raises and lowers the whole body, allowing the body to rest on the floor only a second between times. Each time the body was raised it counted one point. No child was permitted to do more than 50 push ups and 18 of the 20 who reached this limit were in the high percentile group.

According to Heaton this experiment showed that those children who rate high in intelligence tests have an average level of physical development that is superior to those that rate low in intelligence.

After an examination of the historical survey just concluded one can see that the various results submitted have in no way solved the problem. The difference in the various criteria used by the investigators to measure physical and mental ability precludes the possibility of making any very specific comparison of the results obtained.

The general results, however, indicate the present status of the problem. Positive results were obtained by Porter, Smedley, Baldwin, Arnold, Wolley, De Busk as well as by Goddard, Simon and Mead working with the feeble-minded and a group including Crampton, King and Foster who used the physiological age as a basis of physical development. On the other hand among the investigators who found no correlation and in some cases a negative one existing between physical and mental ability, are Boas, West, Gilbert, Wissler, Bagley, Hunt, Bickersteth, Johnson and Lincoln.

A group of later investigators using big muscle ability as criteria for physical development were also divided in their conclusions on the subject. Among those who believe the two abilities go hand in hand are Fisher, Wolley and Fischer, Remp and Heaton, while Wilson, Westerdays, Landis, Burt and Nichols found results indicating no definite relationship. The work of Williams, Dowd and Arlett seemed to indicate that play and games are more valuable for the development of alertness than are formal gymnastics.

Frederick W. Cozens (16) of the University of California, after a careful examination of the investigations concerning the relation of big muscle skill to mental ability sums up the status of the problem in the following conclusions:

"With boys and girls of elementary school age three points seem fairly well established:

1. The better developed a boy or girl is for his or her age, the more able he or she is in school work;
2. The general level of physical ability of children who rate high in intelligence tests is distinctly superior to those who rate low in intelligence; and
3. There seems to be a direct relationship between ability in physical tests and promotion or scholastic results.

With regard to the college data, it seems evident that there is only one conclusion to draw; namely, that there is no correlation between physical ability as measured by 'big muscle' tests and mental ability as measured by group or individual tests. Isn't this really what one should expect to find with an unselected group of college men and women? Assuming that boys and girls must have at least average intelligence to get as far in the scholastic world as college, shouldn't we really expect to find what we do find? It would seem that there ought to be about as many very bright men and women who are proficient in the use of their bodies as there are of the group who are not so bright.

Dr. Garfiel's ventured guess that 'mental and motor ability are different groups of abilities which tend to a very low positive relation say around 0.10 to 0.12 for adult people,' is about as close as we can come to a conclusion at the present time.

Would it be beyond all bounds of reason also to venture a guess that 'big muscle' ability depends to some extent at least on the general physical make-up of the individual, and that there are limits beyond which it is impossible for any individual to go, no matter how much practice is given."

On the basis of Crampton's work it might be suggested that this mental superiority of well developed children of elementary school age may be due to the fact that the one group is farther advanced in physiological maturity than the other.

Hall in his "Adolescence" (31), states that the problem has by no means been solved. Reference is made to Bohannon's work which shows that children who are tall and heavy for their age, are dressed and treated as older children, associate with the more mature and find more is expected of them, all of which treatment tends to force their maturity. On the other hand, for those children who are small for their age the reverse is true, which would tend to delay their development. Hall says, "If Porter's reference that large children are intellectually superior to small ones, is confirmed, it may be at least partly due to artificial and not to natural causes, and the popular conception that rapid growth is likely to be attended by sluggish mentality may yet be true to nature."

In spite of the tremendous amount of confusion which has resulted from the numerous methods of attacking the problem and from the conflicting results obtained there seems to be a growing feeling on the part of the majority of investigators that some factors of physical and mental ability are closely related.

THE PROBLEM

The object of this investigation has been to compare different groups in certain accepted tests of motor ability with reference to their ability to make small muscle movements, and to compare these same groups in a mental factor, which, for the want of a better term, we may call alertness. By alertness here is meant merely the ability to make a quick and accurate response to a given situation. This may be the same factor which Garfiel calls motor adaptability or the capacity to solve motor situations. Thus Garfiel says, that it is easy to see that the subjects differ, not only in speed and strength, but also in their ability to see through a motor situation, that is to make quickly a difficult new reaction. The term "motor adaptability," however, does not seem to be inclusive enough for these reactions, for although it

indicates a psycho-motor process and thereby includes a mental factor, it does not seem that enough emphasis is placed on this mental factor or alertness.

It is generally agreed that measurements of rapidity and accuracy of movements, especially in complex forms of eye-hand coordination are conditioned to some extent by the mental capacity of the individual. Certainly such tests as running, jumping, throwing, and climbing, which are the elements of physical education, are not less influenced by mental ability than are these so-called motor tests, as for example, tapping or strength of grip. It has, however, been claimed that they are measurements of larger muscle groups and of coordination when the whole organism is in action. What, then, is the make-up of the athlete? It is generally agreed that he is superior to the nonathlete in the tests involving large muscle groups, but is this superiority carried over to tests of smaller muscle movements and to the factor of alertness as measured by cancellation and omitted letter tests? May there not, moreover, be differences between types of athletes,—as for example, between those athletes who are members of teams and those who participate only in individual sports? It may be true that there is a factor of alertness which, when coordinated with skill of large and small muscle movements, makes for athletic ability.

The method of approaching this problem in the present investigation was as follows: Three groups were selected; group (1) was composed of team games athletes, that is those people who were successful in athletics involving, primarily team work; group (2) was made up of individual athletes, that is those people who had succeeded in athletics which did not involve team elements; group (3) was composed of nonparticipants in any form of athletics.

The groups were very carefully chosen in the following manner: The athletic director of each school selected for group I those who were the outstanding team athletes of the school; for group II, those who were the outstanding individual athletes of the school, that is those people who were proficient in boxing, golf, track and field events, swimming, tennis, bowling, etc. but who took no part in games involving a team element; group III, those who took no

part in athletics at all. Care was exercised to see that none of the members of group III were there because of any physical defect which would prevent them from taking part in the games if they so desired. In all cases the people chosen were selected because they were typically members of one particular group, disregarding all other considerations. In every school, of course, there are many people who would not belong to any one of these three groups, but to an intermediate one. These people were left out and only those who could be called typical were chosen.

The subjects used in the experiment were chosen from six public schools of Baltimore City and The Johns Hopkins University. Ninety male high school freshmen, thirty in each of the three groups, seventy-five male high school seniors, twenty-five in each group, were the subjects taken from the public schools. Fifty-one male seniors of The Johns Hopkins University completed the groups. In almost all cases the director who selected these subjects had known them for a period of three years.

The team and individual athletes have already shown their ability in the big muscle tests merely by being successful in their athletics, for in order to attain this success, proficiency in running, jumping, throwing and climbing, the elements of physical education is necessary. The question, then, to be answered is: are these people who are superior in big muscle ability and consequently successful as athletes, superior or inferior in ability to make the smaller muscle adjustments and in alertness?

In an attempt to answer this question the following tests were used: (1) a steadiness test, (2) a tapping test, (3) a strength of grip test, (4) an endurance test, (5) a cancellation test, (6) an omitted letter test, (7) a tachistoscopic test and (8) a general intelligence test.

The tests were given in two series: steadiness, tapping, cancellation, omitted letter test, strength of grip and the tachistoscopic tests being given on one day in the order listed. Several days elapsed between this series and the second series which included an endurance test and a general intelligence examination.

APPARATUS AND METHODS

1. The Johns Hopkins Steadiness Plate (24): This was connected with an electric counter, which registered once for every

contact. Five holes were used; the fifth, sixth, seventh, eighth and tenth in a series from large to small. The plate was adjusted so that the hole was brought on a level with the shoulder of the reactor, who stood during the test. The subject was tested with the right hand only, for fifteen seconds in each of the five holes, beginning in the largest one and continuing in order.

The position of the reactor in this test was determined in the following manner. The subject was asked to rest his right arm against his side, take the stylus in the right hand, and holding it in pencil fashion, to insert the tip in the hole indicated, allowing the tip to rest against the side of the hole. He was further instructed to take one step back so as to free the arm from the body and at the word "go" to free the stylus from the side of the hole and hold it so that no contacts should be made, if possible, until told to "stop."

2. The Johns Hopkins double tapping plate (24) was used in an attempt to eliminate any possibility of tremor tapping. This plate was connected with an electric counter as was the steadiness plate. The plate rested on a table of ordinary height, the reactor standing for the test.

The subjects were instructed to hold the tapping stylus in the right hand in regular pencil fashion and to rest the left hand on the table. The further instructions were: to begin tapping at the word "go" and to continue tapping alternately on the right and left plate as rapidly as possible until told to "stop." A period of thirty seconds was allowed for tapping.

3. A Smedley dynamometer (47) was used for the strength of grip test. After the grip had been adjusted to the size of the subject's hand, he was told to take the dynamometer in his right hand to grip it as hard as possible. The reactor was further instructed that when he had pulled as hard as possible he could release his grip and return the dynamometer to the instructor. Three trials were given for each hand.

4. A Smedley dynamometer (47), metronome and stop-watch were used in the endurance test. The subject was seated with his right arm resting on a table. The metronome was set at 60, that is, so that it beat once per second. The dynamometer was

adjusted to the subject's hand and he was told that at the word, "now" he was to grip as forcibly as possible, and to maintain this grip with his utmost effort until told to stop at the end of one minute. During this time he was to keep his eyes fixed on the pointer so that the slightest release of grip would be apparent to him and cause him to renew his effort. The further instructions were that since the strength record had been taken before, the instructor knew what the subject could do and that this work was to be equaled if possible. The instrument was held in the vertical plane with the right-hand edge resting on the table before which the subject was seated. The position of the hand on the dynamometer was recorded on every fourth beat of the metronome, making sixteen records during the minute. The stop-watch was used as a check on the metronome.

5. The cancellation test consisted of a single sheet which contained fifty of each of the twenty-six letters of the alphabet, arranged in chance order, but with precaution against the repetition of any letter within two places. The form was placed before the subject, with the printed side down. The instructions were to turn the sheet over at the word "go," begin with the first line and to cross out every "a" on the page. (Here the instructor demonstrated how they were to be checked so that no unnecessary time would be lost.) The subject was further instructed to mark as rapidly as possible but not to miss any "a's." The watch was started when the subject glanced at the first line, and stopped when he finished the last line.

6. The Dunlap Omitted Letter Test was given with a time limit for each half of the sheet. The test is one in which two columns of words are presented with two letter groups. The subject is to cross out in each word the letter which is missing from the letter group at the right of the word, the variation being that if there are two or more letters alike, either letter may be crossed out. The students were allowed two minutes for each half of the sheet.

7. The Tachistoscopic tests were as follows: The subject was told that he was going to be shown a group of slides with an exposure time of one-tenth of a second and in order to give him some idea of this time, one sample slide was shown. The subject was

further instructed that the examiner would always say "ready" before releasing the slide, and that after this signal was given, the reactor was not to move his eyes. The first half of the test consisted of eight slides, containing diamond shaped dots arranged in no particular order. The smallest number of dots appearing on any card was four and the largest, eleven. The slides, however, were shown in the following order: 8-4-5-10-7-11-9-6. The subject was told that the cards would show diamond shaped dots and was asked to report just how many dots he thought were on each card. The second test consisted of nine slides with printed letters and numbers ranging from two, on the first card, to ten on the last card. The subject was asked to report just what letters and numbers he had seen on each card.

8. Form Six of the Army Alpha General Intelligence Test was given and the chronological age in years and months was taken for all the subjects.

SCORING

The tests used in the investigation were graded in the following manner:

Tapping. The total number of taps registered on an electric counter in thirty seconds was the score for the test. Each subject was given only one trial.

Strength of Grip. Three trials were allowed with each hand. The best record of the right hand was added to the best left hand record for a total strength score.

Steadiness. The number of contacts made in each hole used in the test were added together for a total steadiness record. The groups were also compared as to their abilities in the separate holes.

Endurance. An average of the sixteen records taken in the endurance test was divided by the best record made in the strength of grip test, thereby giving the per cent of strength retained during the examination.

Omitted letter. The omitted letter test was given in two two minute periods, the marks for each separate period, as well as the total for the test, being used as the subjects' scores.

TABLE 1
Junior high school seniors—boys

	TEAM ATHLETES			INDIVIDUAL ATHLETES			NONATHLETES		
	Average	Range	S.D.	Average	Range	S.D.	Average	Range	S.D.
Tapping.....	150.96	121-206	21.0	148.93	117-209	19.9	142.03	100-180	21.5
Steadiness.....	71.36	11-207	43.3	86.93	16-203	43.6	109.8	38-207	48.4
Strength of Grip.....	94.83	60-130	14.6	81.3	43-123	19.9	73.52	38-116	18.8
Endurance.....	66%	40-90%	11.1	64.63%	44-94%	12.55	58.63%	21-91%	14.9
Omitted Letter.....	21.3	10-31	5.44	20.33	0-33	6.62	15.96	0-33	8.12
Cancellation.....	187.73	119-330	50.5	196.83	105-314	50.3	210.37	91-334	51.5
Test 1 Army Alpha.....	8.56	5-12	1.79	7.76	3-11	1.78	7.2	2-11	1.99
Tachistoscope (dot).....	49.97	16-57	7.24	48.9	3-59	10.07	48.17	16-59	9.87
Tachistoscope (L.N.).....	26.26	17-36	5.28	25.80	8-34	5.37	25.56	19-37	3.78
Army Alpha (total).....	97.03	62-156	21.3	91.26	57-128	16.9	91.63	46-132	22.8

Cancellation. The time required to finish the sheet was used as the subject's score. A separate accuracy score of letters omitted was also calculated.

Tachistoscope. Two separate scores were calculated in the tachistoscopic test. The number of letters and figures correctly reported was used as the score for the letter figure series, while in the dot pattern test, the score was sixty minus the differences between the number reported by the subject for each pattern and the true number.

Army Alpha. The Army Alpha was scored in accordance with the regular scoring rules for the test, test I being scored separately as a measure of alertness.

TABLE 2
Junior high school seniors—boys

	TEAM-NON.		TEAM-IND.		IND.-NON.	
	Diff.	P.E.D.	Diff.	P.E.D.	Diff.	P.E.D.
Tapping.....	10.89	3.69	2.03	3.55	6.60	3.60
Steadiness.....	38.44	7.98	15.57	7.56	24.20	8.01
Strength of Grip.....	21.33	2.92	13.53	3.01	7.78	3.36
Endurance.....	7.37	2.29	1.37	2.03	6.0	2.40
Omitted Letter.....	5.34	1.21	0.97	1.05	5.37	1.29
Cancellation.....	20.64	8.87	7.1	8.76	13.54	8.85
Test 1 Army Alpha.....	1.36	0.33	0.8	0.31	0.56	0.33
Tachistoscope (dot).....	1.8	1.5	1.07	1.53	0.73	1.73
Tachistoscope (L.N.).....	0.70	0.80	0.46	0.93	0.24	0.81
Army Alpha (total).....	5.40	3.84	5.77	3.34	0.37	3.48

RESULTS

Section I

In the discussion of the results of the investigation, attention will be paid first to the junior high school group. This section was composed of ninety male subjects, thirty in each of the three groups. The results are presented in tables 1 and 2 and in figures 1 and 2.

The team athletic group scored the highest average in all of the four tests of motor ability, the individual athletes being second and the nonparticipants lowest in each case. In the tapping test

the team group scored an average of ten taps more than the nonparticipants, but only two taps more than the individual group. Although this is the smallest difference shown between the team and nonparticipant groups in any of the motor tests, it is high enough to be considered fairly significant. The difference appears most noticeably at the extremes of the curves, six of the thirty nonparticipants being below 120, while only two individual athletes and none of the team game boys fall below this score. Four of the team athletes, however, were above 180, while only two individuals and no nonparticipants reached this height. The double tapping tests seemed to require an added feature of coördination in going quickly from one plate to the other, and from a general observation of those tested, this factor seemed to the investigator to be giving considerable trouble to the nonparticipants who scored low in the test.

The strength of grip test is especially interesting because it presents the most striking difference of all between the team athletes and the nonparticipants. In this test the team group had an average grip of 21.33 kilograms more than the nonparticipants, with a probable error of the difference only 2.92. The margin of superiority was about equal for each hand, the team group gripping $10\frac{1}{2}$ kgm. more with each hand. Although the team group has the best score in all of the tests given, such marked superiority as that shown in the strength test should in some way be accounted for. No attempt was made in the present investigation to classify the subjects according to physiological age. The chronological age of the subjects was taken and was found to be so close for the three groups that it may be dismissed as attaching no significance to the results. The reactors in this group were, however, between 12 and 16 and therefore in the different stages of maturity. It may be true that the people of this group who are successful as team athletes are so because they are older physiologically. In other words there may be a larger number of post-pubescents in the team group than there are in the group of nonparticipants. If this be true, the exceptional superiority of the group in the test may thus be explained, for it is probably true that the other tests have added factors which

might make them such that the post-pubescent would not be so likely to excell in them as in the simple strength test.

The difference between the team and individual athletes in strength of grip, while not so great as that between the team and nonparticipant, is, nevertheless, a significant one. The team group averaged 13.53 kgm. more than the individual group, with a probable error of 3.01. An even smaller difference appears in the comparison of the individual group with the nonparticipants. The individuals averaged 7.78 kgm. more than the nonparticipants, this difference being only one-third as great as that between the team athletes and nonparticipants. Here again this difference may, in part, be explained with reference to the physiological age. It may be true that the team group contains the largest number of post-pubescents, and the individual athletic group less than the team group, but more than the nonparticipants. There does seem also to be some basis for the belief that this difference would be revealed to a greater extent in strength than in any other test. This, however, is merely a supposition since the physiological age of the subjects was not taken.

In the control of involuntary movement the team group again proved its superiority, making fewer contacts in each of the four holes used in the steadiness test. The average total number of contacts made by the team group in the four holes was 71.36, as compared with 86.93 contacts for the individual group and 111.13 contacts for the nonparticipants. The nonparticipants, then, averaged 38.44 contacts more than the team athletes, with a probable error of the difference 7.98. The gap between the groups widened with each successive hole. In hole no. 5 which is $\frac{1}{4}$ of an inch in diameter the team athletes averaged 3.26 contacts in fifteen seconds, while the nonparticipants averaged 7.4 contacts in the same length of time. In hole no. 6, $\frac{3}{16}$ of an inch in diameter, the margin of the difference between the groups was increased to 9 contacts, with the team averaging 15.2 and the nonparticipants 24.46. The greatest difference between the groups is shown in hole no. 7, the diameter of which is $\frac{5}{8}$ of an inch. In this hole the nonparticipants averaged 36.4 contacts as against only 21.63 made by the team group. In hole no. 8, $\frac{9}{16}$ of an inch in diameter,

the difference was not so great, the team boys averaging 12 contacts less than the nonparticipants. The range of holes used in the experiment was large enough to include a comparison of the large and small movements of the hand and the results indicate that in both cases the team athletes are superior.

A fifth hole, no. 10, which is $\frac{7}{8}$ of an inch in diameter, was also included in the test, but the records are not included here in

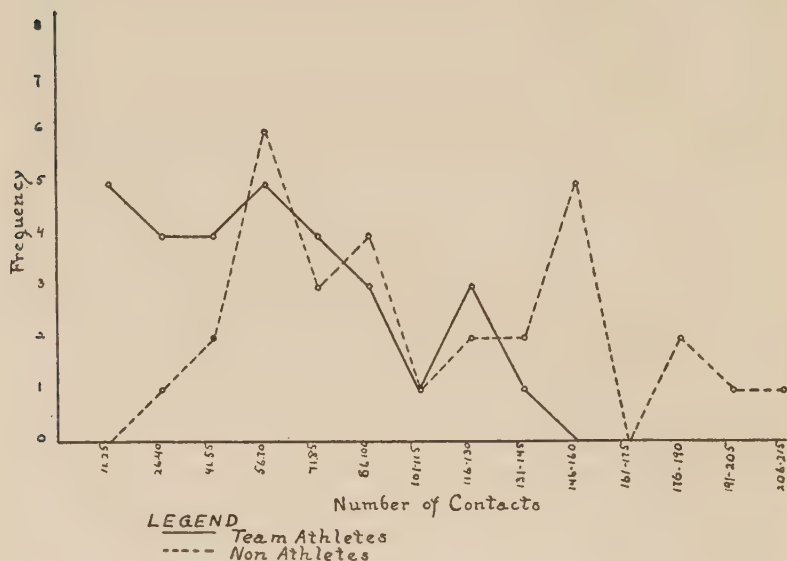


FIG. 1

the results. It was noticed that in this very small hole some of the subjects who had made very poor records in all of the previous holes were able comparatively to improve their score considerably. This was due to the fact that some of these subjects seemed to be unable to keep the stylus away from the sides of the plate at all in this hole. In attempting to move the stylus from one side of the plate they would invariably carry it over to the other side and often keep it in contact with the plate for a second at a time. Thus they would be in contact with the plate for a long

period of time, but the actual number of contacts registered by the clock would not fairly represent this time. Moreover, the number of contacts in this hole was almost invariably over fifty, sometimes as many as one hundred, and since it is extremely difficult to be accurate when the contacts are above forty, it was deemed advisable not to use this hole.

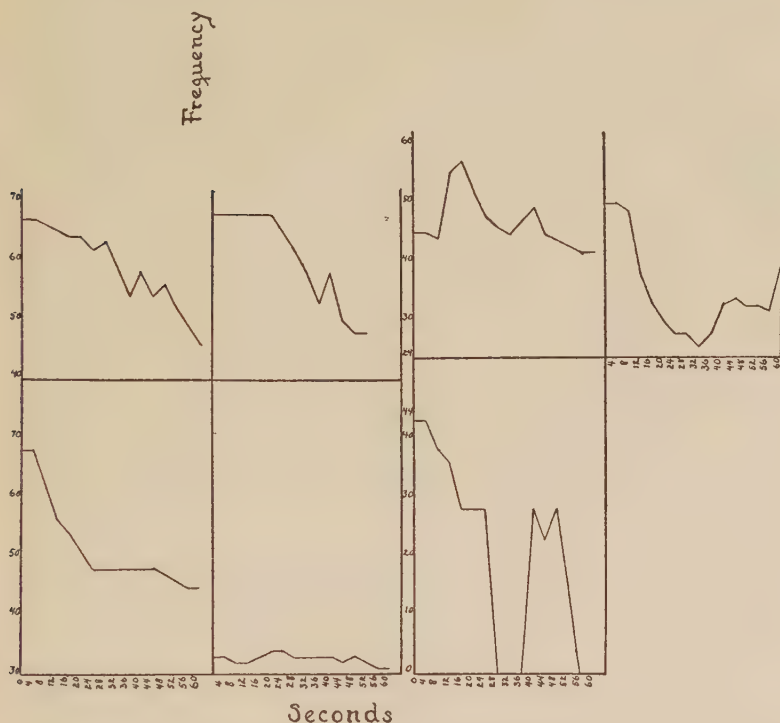


FIG. 2

A glance at the extremes of the curves (fig. 1) of the team and nonparticipant groups shows clearly the superiority of the former. Only one team athlete made more than 140 contacts, while 10 nonparticipants, or $\frac{1}{3}$ of the entire group, exceeded this amount. On the other hand, seven team athletes made less than 40 contacts as compared to one in the nonparticipant group.

The endurance test proved to be the most interesting of the motor tests used. In this test the team athletes maintained an average of 66 per cent of their strength during the minute. The individual group was again the middle one, maintaining an average of 64.63 per cent of their strength, while the nonparticipants were last, with an average of 58.63 per cent. These figures demonstrate significant differences between team subjects and nonparticipants and between individual and nonparticipants, but a very close relationship between the team and individual groups. The records, however, do not show many of the features of the individual curves. Several different types of fatigue are shown in the individual records and some of these types seem to be much more numerous in one group than in the others. The types of curves which are most numerous are (fig. 2):

1. The maximal grip at the beginning, with a steady decline and very slight recoveries.
2. The maximal grip at the beginning, held constant for several seconds, and then a rapid decline with slight recoveries.
3. The grip maintained at practically the same level throughout.
4. The maximal grip at the beginning with a rapid decline to a position which is maintained throughout.

The other types of curves noted which do not appear so frequently are:

5. The maximal grip reached at about $1/3$ the duration of the test, and then a steady decline with slight recoveries.
6. The maximal grip at the beginning with a rapid, steady decline and and then a slow, steady increase.
7. The maximal grip at the beginning with a rapid decline to zero—then another grip almost to the original level followed by another rapid decline approaching zero at the end of the test.

This last type was found only in the nonparticipant group and seemed to be the type of curve presented by the nonparticipant who pulled up as far as his best strength record and then had fatigue set in very rapidly. Type no. 3, in which the grip was maintained at practically the same level throughout the test, was found in the records of both the individual and nonparticipant groups, but not at all in the team game group. This type was,

in all probability, due to the fact that the subject gripped the dynamometer far below his strength record. It is interesting to note that types 1 and 2 were most frequent in the team game group.

The relation between the best grip in the endurance record and the highest pull in the strength test was especially interesting. Although the subjects were urged to pull the dynamometer up as far as their best strength record and then to hold it there if possible, almost all of them failed to reach this height and a large number of them pulled considerably lower. Just what brought about these conditions it is impossible to say. The subject may or may not have been attempting to defeat the purpose of the examination by not pulling as far as possible and thus being able to hold the dynamometer at a constant mark for a greater length of time. Some of the differences may be attributed to the fact that the tests were taken under different conditions, the subject standing in the strength test, and sitting, resting the dynamometer on a table, in the endurance test. Many of the extreme differences, however, could in no way be explained by this difference in method. It is important to note that the team games athletes are much less numerous here than are the members of the other two groups. One question which will naturally be raised is whether or not these types of curves are due to chance, and whether the same subjects may not at another time produce an entirely different kind of curve. In answering this question reference must be made to Doreus (23), who found that individuals tested several times over a period of six months tended to show the same general types of curves.

The performances of the team and individual groups in the omitted letter test were very much alike, both of them being far superior to the performance of the nonparticipants. Here again, as in all of the tests of motor ability, the team athletes made the highest average, the margin over the individual athlete, however, being a very scant one. A very noticeable difference is shown between the team and nonparticipant groups, the former having an average of 21.3 as compared with 15.96 for the latter. The difference of 5.34 must be considered a highly significant one in

view of the fact that the probable error of the difference is only 1.21. The test was given in two periods of two minutes each and the results seem to indicate that the team athletes are not only superior in ability to perform the test at the beginning, but that this superiority is increased with practice.

The results of the cancellation test show no change in the order of the groups, although the margin of superiority of the team athletes is not so marked as in the preceding test. The team group proved to be 20.64 seconds faster than the nonparticipants, and 7.1 seconds faster than the individuals. Here, again, as in the omitted letter test, the difference is more noticeable at one end of the curve than at the other. Eight of the team athletes completed the test in less than 150 seconds, while only three nonparticipants were able to do this well. While it is true that the best time was made by one of the nonparticipants, an examination of the records shows this individual to be the most inaccurate member tested. This particular subject failed to cross out .27 of the 50 A's listed, thereby, really completing less than half the test. It is interesting to note that in each case the fastest group was the most accurate. The team group averaged 2.7 errors as compared with 4 errors made by the individual group and 5.36 by the nonparticipants.

Test 1 of the Army Alpha was scored separate in as much as it was believed to be a good measure of alertness as the term is defined in this paper. The team athletes scored the highest average in the test and again displayed a marked superiority over the nonparticipants. In this test the team group averaged 8.56 out of a possible score of 12. The individual group averaged 7.76, and the nonparticipants 7.2. The difference between the team and nonparticipant groups was 1.36 with a probable error of .33.

In the tachistoscopic tests, while the same group order was preserved, the differences were so small as to be considered negligible. In the letter-figure half of the test the team group scored an average of 26.26, the individual group 25.80 and the nonparticipants 25.56. In no case was the difference between the averages of any of the groups as large as the probable error. Practically the same thing is true of the dot pattern test, the team group aver-

aging 49.76, individuals 48.9, and nonparticipants 48.10. Since this is the first test in which the team group has failed to demonstrate a significant superiority, it is interesting to note that it is the only one which does not involve a type of hand-eye coördination. An examination of the records reveals several interesting facts. In the dot pattern test, in almost every case, the difference between the number reported by the subject and the number of dots actually on the card is constantly either plus or minus. That is, if the subject's error on the first card was a plus one, the rest of his errors tended to be plus, and vice versa. This seems to indicate that for most subjects the first card was the important one and the rest of his reports were based on this card. The subjects who reported that they attempted to get the numbers by groups had a much better score than the others.

In the letter-figure series the subjects reported figures correctly much more frequently than they did letters. In a discussion immediately following the test, a majority of those tested reported the figures being easier to get. Whether or not this condition was partly due to a more prominent place given the figures on the cards cannot be decided at this time. The number of letters on the total series of cards exceeds the number of figures by 2 but it is impossible to say, without further experimentation, which group has the greater number of important positions. There seemed also to be a general tendency, although no dogmatic statement could be made regarding it, for the subject's score to become lower with the growing complication of the card; that is, subjects who had a perfect record on a six place card were unable to score as many as six in any of the remaining cards between six and ten.

The Army Alpha Test of General Intelligence presents the only reversal in order of the groups of Junior high School pupils. The team athletes again had the best score with an average of 97.03, the nonparticipants were second with an average of 91.63, and the individual athletes last with 91.26 average. In no other test, with the exception of the tachistoscopic ones, are the groups so close together. Although the team athletes have an average of 5.40 better than the nonparticipants and 5.77 better than the

individuals, in neither case is the P.E. twice the size of the difference. The low score made by the individual group comes as a surprise since they have always been the middle group and in most cases have had scores closer to the team group than to the nonparticipants. The results of this examination may, however, indicate that the groups are nearly equal in general intelligence but differ in alertness. The parts of the examination in which the athletes are superior are tests 1 and 6, both of which seem to be tests of alertness.

In summarizing the results obtained from the Junior High School subjects, the following points seem to be justified:

1. The team athletes show a marked superiority over non-athletes in motor ability.

2. The team athletes are also far superior to the non-athletes in alertness, the tachistoscopic tests being the only ones which do not show significant differences in their favor.

3. The team athletes have better scores than the individual athletes in all of the tests of motor ability and alertness, but the only differences large enough to be considered important are found in steadiness and strength of grip.

4. The individual athletes are better than the nonathletes in motor ability, although the difference in ability to make small muscle adjustments is not so marked here as between the team and nonparticipant groups.

5. The individual athletes have higher scores than the non-athletes in all of the alertness tests but in only two of these tests are the differences large enough to be significant.

6. The groups do not differ much in general intelligence as measured by Army Alpha.

Section II

The senior high school group was composed of seventy-five male and seventy-five female members of the senior class. The male group included twenty-five team game athletes, twenty-five individual athletes and twenty-five nonparticipants. The results of the tests of motor ability while not exactly like those obtained

TABLE 3
High school seniors—boys

	TEAM ATHLETES			INDIVIDUAL ATHLETES			NONATHLETES		
	Average	Range	S.D.	Average	Range	S.D.	Average	Range	S.D.
Tapping.....	167.4	126-191	17.7	160.36	115-216	25.3	159.76	120-203	18.4
Strength of Grip.....	115.12	89-142	14.2	108.68	81-126	11.0	102.28	63-135	17.4
Steadiness.....	38.96	6-84	20.9	45.44	3-126	32.7	48.0	1-153	31.8
Endurance.....	74.16%	55-97%	10.7	68.08%	47-87%	9.12	62.44%	49-81%	8.08
Omitted Letter.....	29.60	20-40	5.33	25.92	6-40	7.51	25.48	10-54	9.68
Cancellation.....	162.52	121-235	34.0	166.40	127-237	35.8	170.28	122-261	33.0
Test 1 Army Alpha.....	9.6	6-12	1.65	8.52	5-12	1.96	8.24	2-12	2.15
Tachistoscope (dot).....	48.16	17-57	8.60	46.4	21-56	7.99	45.88	7-59	10.9
Tachistoscope (L.N.).....	28.6	13-34	5.46	29.36	23-36	3.49	28.6	17-43	5.63
Army Alpha (total).....	130.52	86-186	21.8	142.92	90-185	25.2	135.32	65-188	2.81

from the junior high school group do tend toward general agreement.

The difference between the tapping rates of the team and non-participant groups is almost exactly the same as the difference between these same two groups of junior high school boys. The team group averaged 167.4 taps in thirty seconds, the individuals 160.56 and the nonparticipants 159.76. The individual athletes are, however, very close to the nonparticipants instead of to the team athletes as they were in the younger age group. The high school seniors of both have an average of seventeen taps more than the high school freshmen.

TABLE 4
High school seniors—boys

	TEAM-NON.		TEAM-IND.		IND.-NON.	
	Diff.	P.E.D.	Diff.	P.E.D.	Diff.	P.E.D.
Tapping.....	7.64	3.44	6.84	4.17	9.8	4.23
Steadiness.....	9.04	5.13	6.48	5.23	2.56	6.15
Strength of Grip.....	12.84	3.04	6.44	2.42	6.40	2.78
Endurance.....	11.72	1.81	6.08	1.89	5.64	1.64
Omitted Letter.....	4.12	1.49	3.68	1.24	0.44	1.66
Cancellation.....	7.76	6.39	3.88	6.66	3.88	6.57
Test 1 Army Alpha.....	1.36	0.36	1.08	0.34	0.28	0.39
Tachistoscope (dot).....	2.28	1.88	1.76	1.58	0.52	1.82
Tachistoscope (L.N.).....	Even	1.05	1.30	0.88	1.30	0.89
Army Alpha (total).....	-4.80	4.8	12.40	4.5	7.6	5.1

The strength of grip test shows the team athletes to be 12.84 kilograms better than the nonparticipants, with a P.E. of 3.04. While this is a significant difference it is not nearly so prominent a one as this test produced with the freshmen groups. A partial answer to this difference may be that the question of physiological age is practically eliminated from this group. The chronological age of the subjects is here again very close with the nonparticipant group being just a bit older. There is good reason to believe that all of the subjects in this section are postpubescents. The team athletes also proved to be quite superior to the individual athletes

in this test averaging 6.44 kgm. better with a P.E. of 2.42. The individuals in turn proved to be 6.4 kgm. stronger than the non-participants. The evidence then seems to be very conclusive that the team athletes are stronger than the individual athletes and nonparticipants and that the individual athletes are stronger than nonparticipants. The differences were a little more noticeable with the left hand than with the right, which may indicate that the use of the left hand in athletic contests is a factor in the development of this member.

The endurance test produced some striking differences with the high school groups. In this examination the team athletes proved to be exceptionally superior to the others, maintaining an average of 74.16 per cent of strength during the minute tested. The other groups fell considerably below this mark the individuals having an average of 68.08 per cent and the nonparticipants only 62.44 per cent. These figures show a superiority of 11.72 per cent for the team group over the nonparticipants, with a P.E. of only 1.81. To some extent these results might have been expected since it is to be supposed that the amount of physical endurance necessary in the programs of high school athletics is large. There is a question, however, regarding the amount of physical endurance displayed in team and individual athletics. Some authorities have claimed that the fast team games such as basket-ball, lacrosse, soccer and football require more endurance than any other physical feats. Anyone, however, who has ever participated in or even been an observant spectator at a track and field or swimming meet, must realize the tremendous amount of endurance the contestant is called upon to show. An examination of the endurance curves shows the marked superiority of the team athletes. Thirteen of the twenty-five nonparticipants are below 60 per cent, while only three of the team athletes fall this low in the scale. The records show a significant superiority of team athletes over individual athletes and of both the team and individual groups over the nonparticipants. The individual curves of the subjects present many interesting facts which are blotted out by the group records. All but one of the seven general types of curves found in the freshman group were presented in the results of the seniors. The

types of curves in which the maximal grip was given at the beginning with a rapid steady decline and then a slow steady increase, were not found at all in the senior groups. The different types of curves were fairly well spread out over the three groups although some types were more numerous than others in the particular groups. In the team games groups two types appeared more often than the others. The maximal grip at the beginning, held constant for several seconds, and then a rapid decline with slight recoveries was the type especially characteristic of this

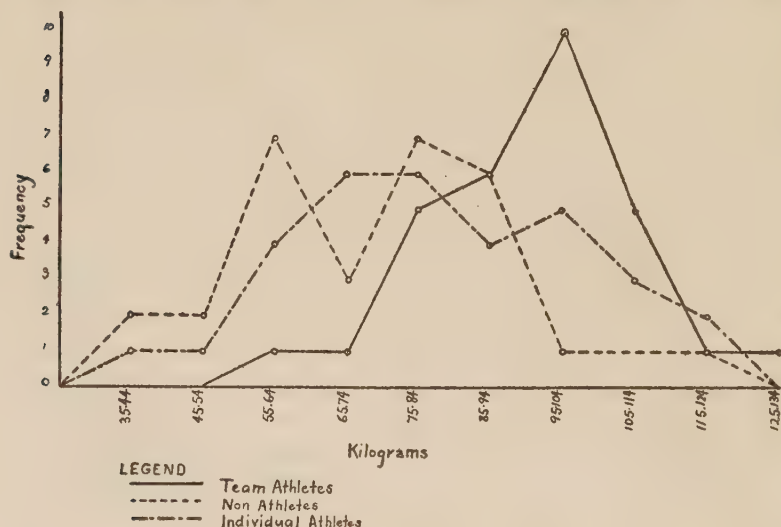


FIG. 3

group. The other type of curve which appeared rather often in this group was—the maximal grip at the beginning with a steady decline and slight recoveries. A few members of the nonparticipant group showed the same general type of curve which was peculiar to this same group of high school freshmen. This is the type in which the maximal grip is given at the beginning, with a rapid decline to zero—then another grip almost to the original level followed by another rapid decline approaching zero at the end. Both the individual and nonparticipant groups present

some curves in which the grip is maintained at approximately the same level throughout. In most of these cases the highest point of the curve is considerably lower than the best mark made by the subject in the strength test. In the actual athletic encounters it is probably true that the team and individual athletes are called upon to demonstrate endurance of different types. In most cases the fatiguing feats for the team athletes are spread out over a long period of time with some opportunity for rest. The athletic feats of the member of the individual group more often means

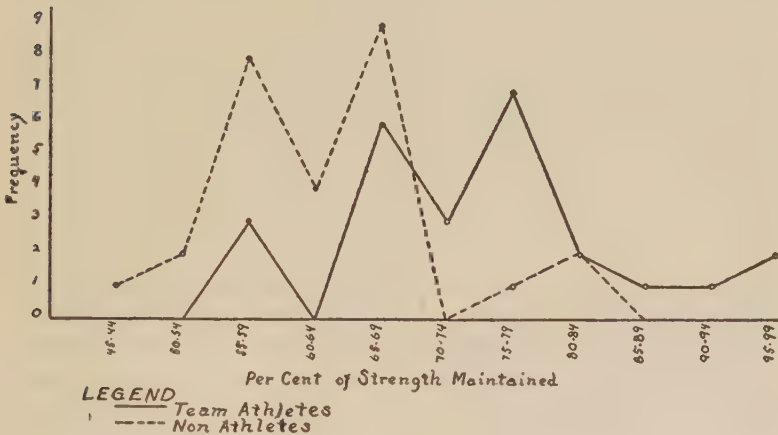


FIG. 4

giving an extreme amount of energy in a short period of time. There are, of course, some exceptions to this as for example the distance runs. In view of these conditions it might be supposed that the individual athlete would make the better endurance record since the test was a continuous one for a short period of time. The dynamometer test is, however, a very different thing from the actual athletic competition. The action is more or less restricted to a small group of muscles and may be only a test of specific endurance. There are, however, a number of conditions necessary for a successful completion of the test and the significant

superiority of the athletes is worth mentioning, whether the test be one of grit or endurance.

In the control of involuntary movement the team athletes again had the best score although the difference between the groups in the steadiness test was less than that obtained in any of the motor tests. In the three holes tested the team athletes made an average of 38.96 contacts, the individuals 45.44 contacts and the nonparticipants 48.0 contacts. While these figures show the team athletes to have made an average of 10.96 contacts less than the nonparticipants with a P.E. of the difference only 5.13, there is no approximation to the marked difference which appeared between these two groups with the high school freshmen. Eight members of the team group were able to make less than twenty contacts while only three of the nonparticipants were able to do so well. Holes no. 6, 7 and 8 ($\frac{3}{16}$, $\frac{5}{32}$, $\frac{9}{64}$ inches in diameter respectively) were used for the seniors' records. The difference between the averages of the team and individual groups was 6.48 with a P.E. of 5.23. The individuals in turn only surpassed the nonparticipants by 2.56 with a P.E. of 6.15. An analysis of the holes taken separately shows the same general order of team, individual, nonparticipant with the exception of hole no. 6 in which the nonparticipants proved a bit steadier than the individuals, the former making an average of 7.28 contacts, while the latter made 8.0. In this hole the team athletes made only 5.08 contacts. In hole no. 7, the team group averaged 12.12 contacts, the individuals 13.76 contacts and the nonparticipants 16.48 contacts. The group records show the nonparticipant group with 8 and 6 subjects respectively making more than twenty contacts while only three of the team athletes proved to be this unsteady. In the last hole tests (no. 8) the groups are very close together, the individuals and nonparticipants being separated by less than 1 contact. The team group made 21.76 contacts, the individuals 25.68 and the nonparticipants 24.24 contacts in this hole. The high school seniors show an exceptionally better record in this test than do the freshmen.

In the omitted letter test, the team athletes demonstrated a significant superiority over both the individual and nonparticipant

groups. The team group made an average score of 29.60, the individuals 25.92 and the nonparticipants 25.48. These records show the individual and nonparticipant groups to be much closer together than was true in this same test with the high school freshmen. The same general features that were pointed out with the freshmen group are found to exist with the seniors. The team athletes not only had the highest score in both halves of the test but increased their margin of superiority in the second half. Very little can be said, however, of the difference between the individual athletes and nonparticipants in this test. The score of the individual group was only 0.44 better than that of the nonparticipants with a P.E. of 1.66.

The results of the cancellation test show the groups to be in the same position but the differences are much smaller than those found with the freshmen groups. The team athletes averaged 162.52 seconds to complete the test, while the individual and nonparticipant groups finished in 166.40 and 170.28 seconds respectively. The difference between the team and nonparticipant groups is 7.76 with a P.E. of 6.39. This is the only difference in the test which is greater than the P.E. and it is too small to be considered significant. The fastest group proved to be also the most accurate but here again the differences are exceptionally small. The team athletes averaged 1.6 errors per man, the individuals 2.56 and the nonparticipants 2.8.

In test I of Army Alpha the senior team athletes were better than the nonparticipants by exactly the same margin as appeared between these two groups of freshmen. The team groups scored an average of 9.6, the individual group 8.52, and the nonparticipant group 8.25. Both the freshmen and senior groups of team athletes have demonstrated their ability to perform this test in a superior manner, since in each case the difference is more than four times the P.E. The test, however, does present one difference which is not true of the freshmen results. That is the fact that the individual group is almost as low as the nonparticipants in the examination. Although the individual athletes have remained the middle group throughout all of the tests in the high school series, they have, nevertheless, showed a tendency to score not

much higher than the nonparticipants. This is in reverse of the tendency shown in the freshmen records where they group rather closely to the team athletes. A glance at the score of the groups shows very well the superiority of the team athletes. Fourteen of the team group are found with a score above 10, with 12 the highest score possible in the test. Only nine of the twenty-five nonparticipants were able to score this well.

The tachistoscopic test again, as was true with the freshmen subjects, is the only one which does not give an advantage to the team athletes. In the dot pattern test the team group had an average of 48.16, the individual group 46.4 and the nonparticipants 45.88. None of these differences are large enough to be considered important. In the letter number series the team and nonparticipant groups were exactly even with an average of 28.6, while the individuals scored an average of 29.36. This is the only test in the records of both the freshmen and senior groups in which the team athletes have not made the highest score; the difference, however, is too small to be given much weight. It is interesting to note the closeness with which the scores approximate each other not only between the three groups but also between the high school seniors and freshmen. In the letter-number series the seniors are about two points better than the freshmen, while in the dot pattern series the freshmen hold about the same margin of superiority over the seniors. The results of the senior tests agree with those of the freshmen in that more numbers are correctly reported than letters. The same general tendency for a subject who had reported a six place card correctly to be unable to equal this mark in the longer series again appears in the records.

The results of the Army Alpha test of general intelligence present the first major reversal of order of the groups. In this test the individual athletes made the best score with an average of 142.92, the nonathletes averaged 135.32, while the team athletes scored only 130.52. This is an exactly opposite result from that obtained with the freshmen group. This is not only the only test in which the individual athletes have excelled, but in all the tests of this section their scores have been close to the nonathletes rather than to the team athletes who have the highest scores in

all the other tests. The individual athletes have an average of 12.4 better than the team group and in view of the fact that the P.E. is only 4.5 this difference must be considered important. An examination of the individual tests which make up the intelligence examination, is especially interesting. The team athletes have the best scores in tests 1 and 6 which tests seem to be measures of alertness. The tests in which they seem to have fallen down are no. 2 which is arithmetic, no. 4 same and opposite test and no. 8 which is a general information test.

Conclusion. 1. The team athletes are superior to nonathletes in motor ability although, with the exception of the endurance test, the differences are not as great as those obtained between these same groups of junior high school seniors.

2. The team athletes are more alert than nonathletes, although in two of the tests the margin of superiority is not a significant one.

3. The team athletes have better scores than the individual athletes in all of the tests of motor ability and alertness, although only half of these differences are large enough to be considered important.

4. The individual athletes showed a tendency to fall much closer to the nonathletes in this section than they did in the junior high school section, for although their scores are always higher than those of the nonathletes, in only strength of grip and endurance, they are much superior.

5. The individual athletes showed a significant advantage over the team athletes in the Army Alpha test, the advantage being gained especially in test 2, 4 and 8.

Section III

The results of the female high school seniors include some interesting deviations from the records obtained with the male subjects. In the tests of motor ability changes are found in the group order in both tapping and steadiness. In the tapping test although the team athletes have the best score, the nonparticipants have a higher score than the individual athletes. The steadiness test produced a striking result inasmuch as it is the

TABLE 5
High school seniors—girls

	TEAM ATHLETES			INDIVIDUAL ATHLETES			NON-ATHLETES		
	Average	Range	S.D.	Average	Range	S.D.	Average	Range	S.D.
Tapping.....	169.72	138-203	18.0	159.15	133-193	17.1	165.13	134-194	16.1
Steadiness.....	57.77	5-139	32.8	52.95	6-121	27.2	69.15	11-205	55.0
Strength of Grip.....	75.31	62-91	8.1	73.05	61-98	8.19	67.54	54-84	7.45
Endurance.....	73.04%	60-88%	6.37	69.3%	54-90%	9.07	67.0%	49-87%	9.11
Omitted Letter.....	31.64	19-47	8.87	29.45	20-42	5.39	25.5	14-48	7.07
Cancellation.....	153.36	122-210	25.7	146.65	87-280	40.9	157.36	107-211	26.4
Test 1 Army Alpha.....	10.13	3-12	3.75	8.8	4-11	2.16	8.22	3-12	5.09
Tachistoscope (dot).....	43.59	0-58	14.8	45.85	26-57	7.6	41.45	3-56	12.6
Tachistoscope (L.N.).....	29.9	21-40	4.14	27.5	17-36	4.32	28.72	13-44	6.31
Army Alpha (total).....	134.0	93-170	17.2	124.0	105-156	14.8	119.7	98-176	19.1

first motor ability test in the investigation in which the team athletes were not superior. In this test the individual athletes made the least number of contacts, with the team athletes a close second and the nonparticipants the most unsteady.

In the tapping test the team athletes averaged 169.72 taps in thirty seconds as compared with a 165.13 by the nonparticipants and 159.15 by the individual athletes. The only difference between the groups which is of any significance is that between the team and individual groups. The team athletes had an average of 10.57 taps more than the individuals with a P.E. of 3.64.

TABLE 6
High school seniors—girls

	TEAM-NON.		TEAM-IND.		IND.-NON.	
	Diff.	P.E.D.	Diff.	P.E.D.	Diff.	P.E.D.
Tapping.....	4.59	3.46	10.57	3.64	-5.98	3.47
Steadiness.....	11.38	9.2	-4.82	6.24	16.20	8.90
Strength of Grip.....	7.77	1.58	2.26	1.7	5.51	1.64
Endurance.....	6.04	1.59	3.74	1.64	2.3	1.89
Omitted Letter.....	6.14	1.62	2.18	1.51	3.95	1.29
Cancellation.....	4.0	5.3	-6.71	3.64	10.71	7.22
Test 1 Army Alpha.....	1.91	0.427	1.33	0.356	0.58	0.392
Tachistoscope (dot).....	2.14	2.8	-2.26	2.42	4.40	2.14
Tachistoscope (L.N.).....	1.18	1.08	2.4	0.885	-1.22	1.12
Army Alpha (total).....	14.3	3.70	14.0	3.34	4.3	3.54

Nine of the individual athletes failed to score as high as 150 taps in the test, while only two team athletes and three nonparticipants fall below this score.

Another factor worthy of consideration is the fact that the tapping rate of the girls is on the whole higher than that of the boys. The female team group scored an average of 2.32 taps more than the male team group, while the female nonparticipants proved to be 5.37 taps better than the male nonparticipants. The male individual athletes were better than the female individuals by 1.41 taps. In connection with these results it is interesting to note that 42 of the 66 female subjects tested either typed or played the

piano or both, while only 16 of the 75 male subjects were engaged in these activities. Just what effect the typing and piano playing may have on the tapping rate it is impossible to say here. Since the double tapping plate was used, however, there does seem to be some similarity between the movements required in these activities and the double tapping movement.

In the steadiness test the results swing in the other direction, the individual group having the best average, with the team group

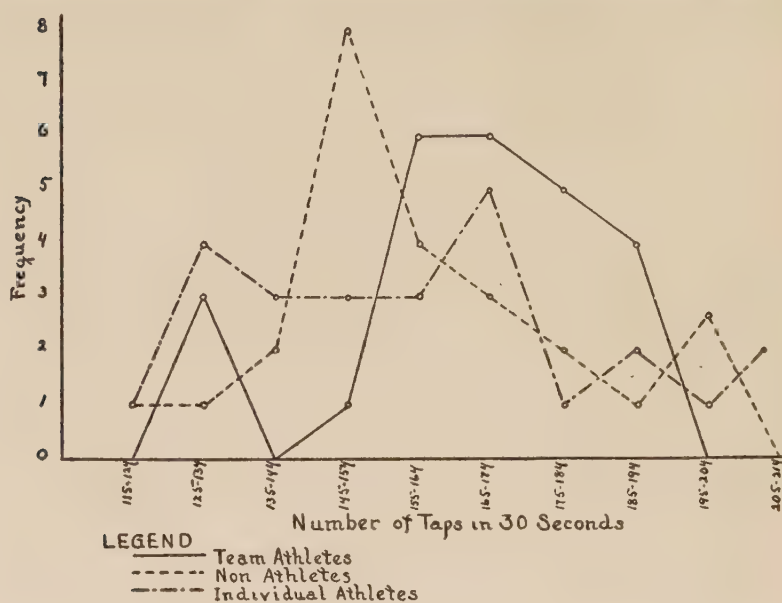


FIG. 5

second and the nonparticipants last. The individual group made an average of 16.20 contacts less than the nonparticipants. The differences between the team and individual and the team and nonparticipant groups are too small to be considered important. A separate analysis of the results of the three holes tested shows clearly that the individual group gained their advantage in the largest hole, no. 6. In this hole they averaged 8.95 contacts, while the team athletes averaged 12.31 and the nonparticipants,

14.72. In hole no. 7, the individual athletes have an average of 17.6 contacts as compared with 18.72 by the team athletes and 23.40 by the nonparticipants. In hole no. 8 the team group drew even nearer the individuals, the former averaging 26.72 contacts and the latter 26.40 contacts, while the nonparticipants made 30.54 contacts. Consider now the records of the male and female team athletes in the steadiness test. The male subjects proved to be much the steadier averaging only 38.96 contacts in the three holes as compared with 57.77 for the female subjects. A difference just as large occurred in favor of the male nonparticipants over the female nonparticipants but the individual groups are a bit closer together, the males averaging 45.44 contacts and the females 52.95 contacts. Seven of the male team athletes and only one of the females made less than 20 contacts in the test, while six of the female team group made more than 80 contacts as compared with one male.

In the dynamometer test for strength of grip the team athletes averaged 75.30 kgm. for the two hands, the individuals 73.05 and the nonparticipants, 67.54 kgm. Both the team and individual athletes demonstrated a significant superiority over the nonparticipants in this test. The team group had an average of 7.77 kgm. more than the nonparticipants with a P.E. of the difference 1.58 and the individual athletes are better than the nonparticipants by 5.51 kgm. with a P.E. of 1.64. The team athletes are only 2.26 kgm. better than the individual athletes and this superiority is all in the right hand, the left hand grips being practically equal.

The results of the dynamometer test for endurance show the group order to be the same as that obtained with the male subjects; the differences between the groups, however, is not nearly so great. The average records of strength retained during the test in terms of per cent are as follows: team athletes 73.04 per cent, individual athletes 69.3 per cent, nonparticipants 67 per cent. The difference of 6.04 per cent between the team athletes and the nonparticipants, while not anything like as great as the difference between these same two groups of male subjects, is nevertheless an outstanding one in view of the low P.E.D. of 1.59. An exami-

nation of the curves representing the individual records made by the subjects in this test reveals some tendencies worthy of comment here. Although seven different types of curves were found in the results of the male subjects, four types, three of which are similar to those found in the male records, seem to be representative of practically all of the female subjects. These four types of curves are:

1. The maximal grip at the beginning with a steady decline and slight recoveries.
2. The maximal grip at the beginning with a steady decline and no recoveries.
3. The maximal grip at the beginning held constant for some time with a rapid decline and slight recoveries.
4. The same grip held fairly constant throughout.

The first two of these types were much more numerous than the others although quite a good number of the records of the team group were represented by type no. 3. A large number of the female subjects fall in type no. 2 which is peculiar to this group, since not one record of the male subjects tested could be represented by this type of curve. Several possibilities might be offered in an attempt to explain these results but since it is impossible to tell whether the female subjects in question were actually unable to make any recoveries, or their attitude towards the test was different from that of the male subjects, no attempt can be made here to explain the appearance of this type of curve. Type no. 4 appears only in the records of the individual athletes and nonparticipants as was also true of the male records. Two of the other types of curves found in the male records occurred twice each with the female subjects. They were:

1. The maximal grip at about 1:3 the duration of the test and then a steady decline with slight recoveries.
2. The maximal grip at the beginning with a rapid decline to a position then maintained throughout the test.

None of the records of the female nonparticipants show a drop to zero in the middle of the curve as was characteristic of some of the male nonparticipants tested. A larger number of female non-

participants, however, were found whose maximal grip in the endurance test was considerably lower than their best pull in the strength test.

While the results of the motor ability tests as a whole show the same general relationship between the groups, as was in evidence with the male subjects, nevertheless, the differences are not so great and there are some changes in the group scores.

The results of the omitted letter test show both athletic groups to be far above the nonathletes. The team athletes had a score of 31.64, the individual athletes 29.45 and the nonathletes 25.5. The difference between the team athletes and nonathletes of 6.14 is especially significant in view of the fact that the P.E. of difference is only 1.62. A sex comparison of the groups in this test reveals the fact that the female team athletes are superior to the male team group, while the female individual athletes are not nearly so good as the male individual group. The scores of the male and female nonathletes are practically the same.

The cancellation test shows another reversal in order of the groups. In this test, as was true in steadiness, the individual athletes outstripped the team group completing the test with an average time of 146.65 seconds. The average time for members of the team group was 153.36 seconds, while the nonathletes required 157.36 seconds to complete the test. The difference, here between the individual and team groups is 4.0 with a P.E. of difference of 5.3. The results show the female subjects to be about 14 seconds faster than the male subjects for all groups, there being practically no difference in accuracy.

In test no. 1 of Army Alpha, the pendulum again swings back in favor of the team athletes. The results of this test, as well as those of omitted letter, have produced surprising results in favor of the team athletes in all the subjects tested. The female team athletes scored an average of 10.13 for the test, as compared with 8.8 by the individual athletes and 8.22 by the nonparticipants. The difference between the groups appears all the more prominent when it is considered that 18 of the 22 team athletes had a score of 10 or better out of a possible high score of 12, while 7 individual athletes and 6 non-athletes made scores this high.

The results of the tachistoscopic tests appeared very much like those obtained from the male subjects. The male subjects were slightly better in the dot pattern test but the scores in the letter-number series were almost identical for the two groups. The order of the groups of female subjects for the two tests was as follows: Dot pattern test—individual—team—nonparticipant. Letter-number test—team—nonparticipant—individual. In no case, however, were the differences between the groups large enough to be credited with significance.

The scores of the Army Alpha Test of General Intelligence indicated a superiority for the team athletes of 10 points over the individual athletes and 14 points over the nonathletes. Since the P.E. of D between the score of the team athletes and the nonathletes is only 3.7 the superiority must be considered an important one. These are the largest differences found between any of the groups in the Army Alpha test. It is interesting also to note that although the female team athletes have a slightly better score than the male team athletes both of the other male groups are considerably higher than the female groups in the test.

Conclusions. 1. The team athletes although lower than the individual athletes in steadiness, are superior to both the individual and nonathletes in all of the other tests of motor ability.

2. The individual athletes are superior to the nonathletes in all of the motor tests except tapping.

3. The team and individual athletes are superior to nonathletes in alertness.

4. In spite of the fact that the individual athletes have a better score in cancellation and in one of the tachistoscopic tests, the evidence seems to point towards a general superiority of the team group in alertness. The team athletes had important advantages in omitted letter and test I of Army Alpha and a better score in a test of the tachistoscopic series, while the differences in favor of the individual group in cancellation and in a test of the tachistoscopic series were especially small.

5. The team athletes are higher in general intelligence rating than both of the other groups.

6. The female subjects proved to be better than the male subjects in tapping, although lower in all of the other motor tests.

7. The female subjects are better than the males in the omitted letter and cancellation tests but have a lower score in general intelligence.

In general the results obtained from the records of the female subjects follow the same general trend as those from the male records. There are, however, some changes in the group scores which do not appear at all in the records of any of the male subjects. Perhaps, some significance may be attached to the fact that the girls' athletics are not organized to the same extent as that of the boys. Athletics for girls comes as a much later development in the educational program and consequently has not reached the same level attained in boys' athletics. It is possible then that the girls' groups may not represent exactly the same interests and accomplishments, to say nothing of the training, as that represented by the boys' groups.

Section IV

The last group of subjects tested was composed of seventeen team athletes, seventeen individual athletes and seventeen non-athletes all members of the senior class of the Johns Hopkins University. The team athletes were again found to be superior to the others in motor ability, but the results of these experiments show a decided difference in the degree of superiority when compared with the results displayed by the junior and senior high school subjects. The most striking difference of all appears in the tapping test. In this examination the college team athletes made an average of 175.23 taps in thirty seconds compared with 165.88 by the individual athletes and only 153.11 by the nonathletes. These figures show the team athletes to be 22.12 taps better than the nonathlete with a P.E. of only 2.38. It will be recalled that with the junior and senior high school subjects, this was the test in which the group scores were closest together. Figure 6 clearly shows the marked superiority of the team athletes in this test. Only three of the nonathletes scored above 158 taps, while not one team athlete scored this low. The individual athletes

TABLE 7
College seniors—boys

	TEAM ATHLETES			INDIVIDUAL ATHLETES			NONATHLETES		
	Average	Range	S.D.	Average	Range	S.D.	Average	Range	S.D.
Tapping.....	175.23	159-191	9.7	165.88	145-182	11.7	153.11	135-180	12.2
Steadiness.....	32.82	7-66	16.5	47.52	14-85	18.5	57.11	25-90	14.8
Strength of Grip.....	128.7	103-158	16.45	122.58	99-149	14.5	121.17	97-148	14.6
Endurance.....	74.59%	60-87%	6.84	71.41%	55-85%	7.58	69.18%	53-85%	8.43
Omitted Letter.....	35.88	23-48	7.83	33.41	23-47	6.75	31.75	23-47	6.18
Cancellation.....	139.18	107-175	20.9	150.47	108-194	25.2	157.35	108-201	25.5
Test 1 Army Alpha.....	9.82	8-12	1.38	9.11	6-12	1.64	8.7	5-12	1.81
Tachistoscope (dot).....	48.58	27-56	7.24	46.88	25-56	7.70	43.65	2-56	12.1
Tachistoscope (L.N.).....	31.17	14-40	6.69	30.06	16-38	5.84	29.76	18-36	4.24
Army Alpha (total).....	153.29	116-186	15.7	151.88	115-175	14.4	148.82	119-174	12.9

are considerably lower than the team group in the test but show a distinct advantage over the nonathletes.

The strength of grip test, in which the junior and senior high school team athletes showed their best advantage, swings in the other direction with the college seniors. Although the college team athletes have the highest score in the strength test, the margin of superiority over the individual and nonparticipant groups is nothing like that shown in the junior high school groups. The

TABLE 8
College seniors—male

	TEAM-NON.		TEAM-IND.		IND.-NON.	
	Diff.	P.E.D.	Diff.	P.E.D.	Diff.	P.E.D.
Tapping.....	22.13	2.38	9.35	2.48	12.77	2.64
Steadiness.....	24.29	3.62	14.70	4.05	9.59	3.88
Strength of Grip.....	7.53	3.59	6.12	3.59	1.41	3.46
Endurance.....	5.41	1.78	3.81	1.67	2.23	1.85
Omitted Letter.....	4.12	1.63	2.47	1.68	1.65	1.49
Cancellation.....	18.17	5.38	11.29	5.35	6.88	5.87
Test 1 Army Alpha.....	1.12	0.37	0.71	0.35	0.41	0.40
Tachistoscope (dot).....	4.93	2.30	1.70	1.73	3.23	2.34
Tachistoscope (L.N.).....	1.41	1.29	1.11	1.45	0.3	1.18
Army Alpha (total).....	4.47	3.32	1.41	3.49	3.06	3.18

college team athletes averaged only 6.53 kilograms more than the nonathletes with a P.E. of the D of 3.59, while the individual athletes were only 1.41 kgm. better than the nonathletes. Again, as was true of the high school group, the superiority of the team athletes was a bit more noticeable in the left than in the right hand.

This extreme change in the trend of results may in part be explained by the fact that the development of muscular control takes place first in the larger and more fundamental muscles and later in those of finer function. Thus the infant learns to move the trunk, limbs, and head, as a whole, earlier than the fingers and toes. Then the increase in control and skill which comes in adolescence begins with the larger muscles and proceeds to the smaller.

As a matter of fact in the earlier years of adolescence, there may be some actual falling off in power of control over the finer muscles, while the more fundamental muscles develop at their expense. This test of strength of grip, is, however, the only one of the motor tests in which the team athletes do not have a significant advantage over the other groups.

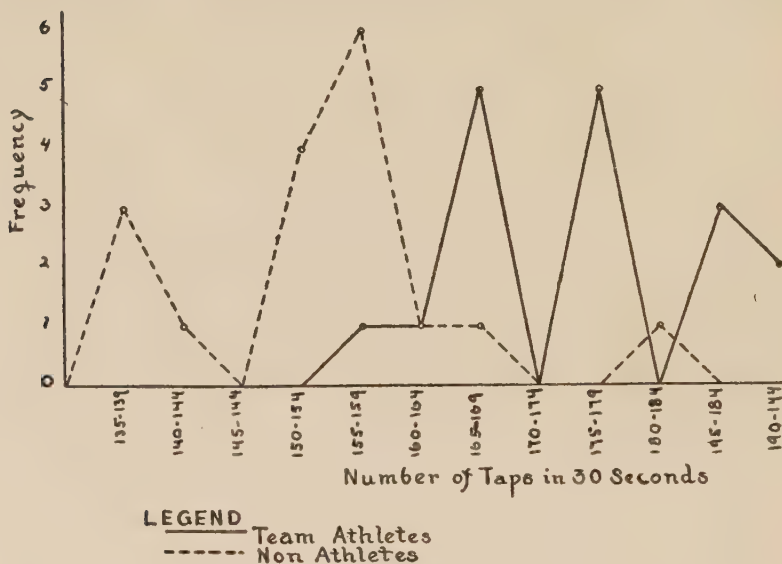


FIG. 6

The total steadiness record, as well as the comparative scores of the individual holes, shows the team athletes to be considerably better than both the individual and nonparticipant groups in the control of an involuntary movement. The total average number of contacts made by the team athletes in the three holes used in the test, was only 32.82. The individual athletes had considerably less control than the team group, with an average total number of contacts 47.52, but were much steadier than the nonathletes who averaged 57.11 contacts for the three holes. The averages for the groups in the three holes are as follows:

College seniors—male—steadiness record

	HOLE 7	HOLE 8	HOLE 9	TOTAL
Team athletes.....	5.64	9.29	17.88	32.82
Individual athletes.....	7.15	13.80	26.57	47.52
Nonathletes.....	10.7	16.82	29.58	57.11

An examination of the individual records of the subjects shows that nine team athletes, or over half of the entire group, made less than 30 contacts in the three holes, while only four individual athletes and one nonathlete were able to do so well.

The results of the dynamometer test for endurance present some interesting facts. The team athletes, with an average of 74.57 per cent of their strength maintained during the minute tested, have the best score. The individual athletes with an average of 71.41 per cent and the nonathletes with an average of 69.18 per cent follow in order. The diverse types of curves presented in the high school records do not, however, appear in the college data. All but five of the fifty-one college subjects present individual curves which fall under three types.

1. The maximal grip at the beginning with a steady decline and slight recoveries.
2. The maximal grip at the beginning with a steady decline and no recoveries.
3. The maximal grip at the beginning, held constant for several seconds, then a rapid, steady decline with slight recoveries.

A fairly equal number of the members of each group are found in types 1 and 2, but in type 3 there are six team athletes, two individual athletes and no nonathletes. The five subjects whose individual curves do not fall in any of these types may be represented as follows:

Practically the same grip maintained throughout the test (two non-athletes and one individual athlete).

The maximal grip at the beginning with a rapid decline to zero—then another grip near the maximum and a steady decline approaching zero again at the end (two non-athletes).

The college team athletes made higher scores than both the individual athletes and nonathletes in all the tests of alertness. In the omitted letter test the team group had an average of 35.88, the individual group, 33.41 and the nonparticipants, 31.76. Nine of the team athletes, or over half of the group, scored above 35 in the test, while only three nonathletes reached this mark. The difference between these two groups is 4.12, and since the P.E.

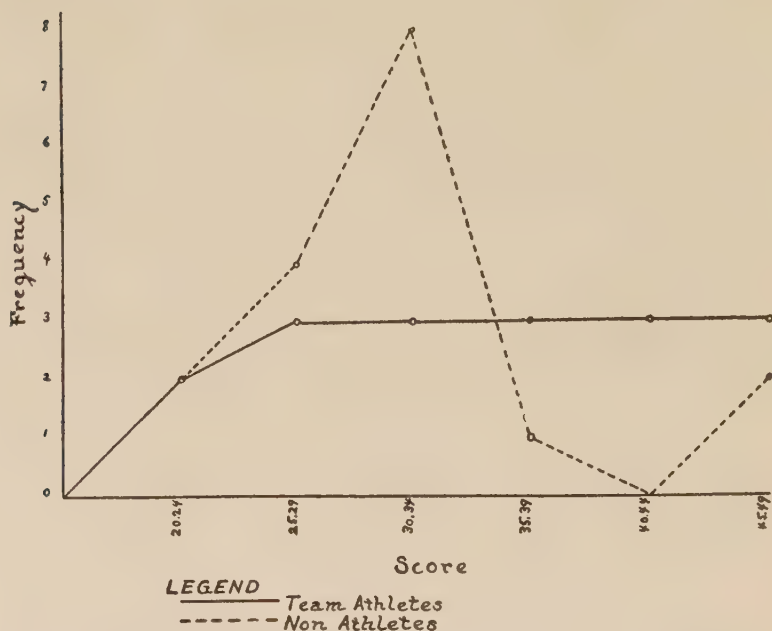


FIG. 7

of D. is only 1.63, this may be considered as a significant difference. The differences between the team and individual and individual and nonathletic groups are too small to be considered important.

The nonathletes required the longest time to complete the cancellation test, the group average being 157.35 seconds. The individual athletes were about seven seconds faster, completing the test in 150.47 seconds, while the team athletes presented a much

better record, completing the test in 139.18 seconds. In each case the fastest group has the best accuracy score, the nonathletes being considerably less accurate than either of the other two groups. In view of these facts, since the team athletes are not only 18.17 seconds faster than the nonathletes but also considerably more accurate, the differences between the groups must be considered as a highly significant one.

In test no. 1 of Army Alpha, the team athletes have an average of 9.82 out of a possible 12, the individual group, 9.11 and the nonparticipants, 8.70. These figures show the team athletes to be 1.12 better than the nonathletes with a P.E. of D. of 0.37.

The order of the groups remains the same in both of the tachistoscopic tests, the team group having the best score, the individual athletes the middle score and the nonathletes the low one. Again, as was found to be true of all the other sections, the differences in these tests were not large enough to be considered important. It is interesting, however, to note that the difference between the team athletic and nonathletic groups in the dot-pattern test is the largest one found between any of the groups in all the tachistoscopic tests. The team group scored almost five points higher, with a P.E.D. of only 2.31. In the letter-figure series the groups were very close together, the team athletes scoring an average of 31.17, the individual athletes scoring an average of 30.06 and the nonathletes, 29.76. The examination of the records shows some of the same general characteristics that were found in the records of the high school subjects. There seems to be a tendency for the subjects to report correctly figures more often than numbers. There also seems to be a tendency for a large number of the subjects to make a better score on the cards which have five and six letters and figures than on the longer ones. Thus, a great number of subjects who reported cards 5 or 6 correctly, failed to name correctly as many as this on the succeeding cards which contain as many as ten letters and figures.

In the Army Alpha Test of General Intelligence the groups were found to be quite close together. The team athletes averaged 153.29, the individual athletes 151.88 and the nonathletes 148.82. None of the differences between these groups are large enough to

be considered significant in view of the fact that all of the P.E.D. were above three. An analysis of the separate tests of this examination shows the team group to be superior in tests 1, 5 and 6 which may be said to be tests of alertness, while the nonathletes have the better scores in tests 2, 4, and 8.

Conclusions. 1. The team athletes are superior to both individual athletes and nonathletes in all of the tests of motor ability, although the advantage in strength of grip is rather small.

2. The individual athletes are decidedly superior to the nonathletes in tapping and steadiness, and although their scores in strength and endurance are not much better, they at least help to indicate the motor ability superiority of the group.

3. The team athletes scored a distinct advantage over the nonathletes in all of the tests of alertness with the exception of the tachistoscopic dot-pattern test.

4. The groups were fairly equal in general intelligence as measured by the Army Alpha.

CONCLUSIONS

The results obtained from the two hundred and eighty-eight subjects tested are analyzable into some very definite conclusions and some less definite ones. There appears to be quite conclusive evidence for the fact that the team athletes are better than nonathletes in motor ability as tested by rapidity of motion, strength, endurance and control of involuntary movement, and in alertness as measured by such tests as cancellation, omitted letter and test 1 of Army Alpha. There may be some doubt, as has already been suggested, regarding the results of the junior high school section. The ages of the members of this group stamp them as being in different stages of maturity, therefore, the physiological age may have been a conditioning factor in the results. The fact that the strength of grip test was the one in which the greatest difference appeared between the age groups also supports this inference. The performance, however, of both male and female high school and male college team athletes, in motor ability and alertness, leaves little room for doubt of the superiority of this group. In the college section the athletes and nonathletes are quite close

together in strength of grip but the athletes are exceptionally superior in tapping, which is what would be expected in the general developmental theory. In general, the order of the group scores was fairly constant, the team athletes having the best score and the nonathletes the lowest one, the individual athletes falling in the middle group. This order was changed in a few places, most noticeably for the girls. There is, however, a difference in the organization and development of girls' athletics which might make their groups not exactly comparable to the boys' groups. Although the results are not so conclusive as those obtained between the team athletes and nonathletes, there does seem to be a general tendency for the team athletes to be superior to the individual athletes and the individual athletes to be superior to the nonathletes in motor ability and alertness. The individual athletes as the middle group are found at one time closer to the nonathletes and at another time closer to the team athletes.

A sex comparison of the high school senior section reveals the following:

1. The high school boys are better than high school girls in all of the motor ability tests except tapping.
2. The high school girls have better scores than the high school boys in the alertness tests although in most cases the differences are rather small.

The scores of the senior high school boys are better than those of the junior high school boys and likewise the college boys surpass the marks made by the high school seniors, in all to the tests with the exception of the tachistoscopic attention tests. In these tests the results show very little variation in the scores of the junior, senior high school and college subjects. In this connection it is interesting to note that these are the only tests in which the athletes consistently failed to show a decided advantage over the nonathletes, and incidentally the only ones which do not involve a type of hand-eye coördination.

The results of the Army Alpha test indicate that there is very little difference between the groups in general intelligence. These differences, in three of the four cases are in favor of the athletes but in no instance are they large enough to be significant. An

analysis of the separate tests of the examination revealed the tendency for the athletes to excel in tests 1, 5 and 6 which seem to be tests of alertness, while the nonathletes were superior in tests 2, 4 and 8 which are tests of arithmetic ability, precision in language and general information.

The results of the investigation would seem to present evidence for these conclusions:

1. That athletes are superior to nonathletes in motor ability and alertness.

2. That there is a difference in motor ability and alertness within the athletic groups, and this difference appears to be in favor of those athletes who participate in team games in contra-distinction to those who take part in individual athletic feats in which there is no team element involved.

3. Athletes are inferior to nonathletes in tests of arithmetic ability, precision in language and general information.

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